Measurement for p–^{3}He elastic scattering with a 65 MeV polarized proton beam

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One of the most important topics of nuclear physics is to describe various nuclear phenomena based on the nucleon–nucleon (NN) interactions combined with the three–nucleon forces ($3N$Fs). $3N$Fs are key elements to understand various nuclear phenomena, e.g. binding energies of light mass nuclei [1] and the equation of state of nuclear matter [2]. In order to study the dynamical aspects of $3N$Fs, such as momentum, spin, and iso-spin dependencies, few–nucleon scattering is a good probe. The first indication of the $3N$F effects in the few–nucleon scattering was found in the cross section minimum for deuteron–proton (dp) elastic scattering at intermediate energies ($E/A \gtrsim 65$ MeV) [3]. As an extension of the study of $3N$F effects in nucleon–deuteron scattering, we performed the measurement for the p–^{3}He scattering at 65 MeV. The motivation of this experiment is to explore the $3N$F effects in four-nucleon scattering as well as to approach to the $3N$Fs with the channels of the total iso-spin $T = 3/2$.

The measurement for p–^{3}He elastic scattering was performed in the west experimental hall of the RCNP cyclotron facility. Figure 1 shows the schematic view of the experimental setup. The polarized proton beams were provided by the High Intensity Polarized Ion Source and they were accelerated by the AVF cyclotron up to 65 MeV. After bombarding the ^{3}He gaseous target in the scattering chamber, the beams were stopped in the Faraday cup. The beam intensity was 20 – 100 nA. The polarization of the beam was measured by using the beam line polarimeter. The polarimetry was made by p–^{12}C elastic scattering. The typical beam polarizations were 45–55 % of the theoretical maximum values. In the experiment, the ^{3}He gaseous target was operated at the room temperature under the atmospheric pressure. The scattered particles were detected by the ΔE–E detectors which consisted of plastic and NaI(Tl) scintillators. The effective target thickness of the gaseous target and the solid angle of the detectors were determined by using the double slit collimator. The measured angles were 26.9°–170.1° in the center of mass system. In addition, we performed the measurement for pp elastic scattering using H_2 gaseous target in order to calibrate the absolute value of the cross sections for p–^{3}He elastic scattering.

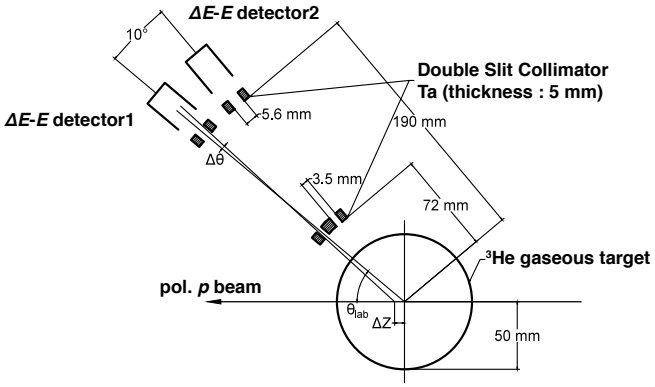

Figure 1: Schematic view of the experimental setup

Figure 2 shows the preliminary experimental results of the cross sections and the proton analyzing power A_y for p–^{3}He elastic scattering as a function of the scattering angle in the center of mass system. Solid circles are the experimental data. Only the statistical errors are shown. The solid lines are the rigorous numerical four–nucleon calculations based on the several realistic NN potentials (Doleshall, CD-Bonn) [4]. The angular distribution of the experimental data has a moderate agreement with the theoretical calculations. Especially,

the data of forward and backward angles are well reproduced by the calculated results. However, for the cross sections, large differences are found at the angles $\theta_{\mathrm{C.M.}} \sim 80°$–$130°$ between the data and the calculations. For the proton analyzing power A_y, clear discrepancy are seen at the angles where A_y takes maximal and minimal values. These are the preliminary results, hence data analysis is in progress now.

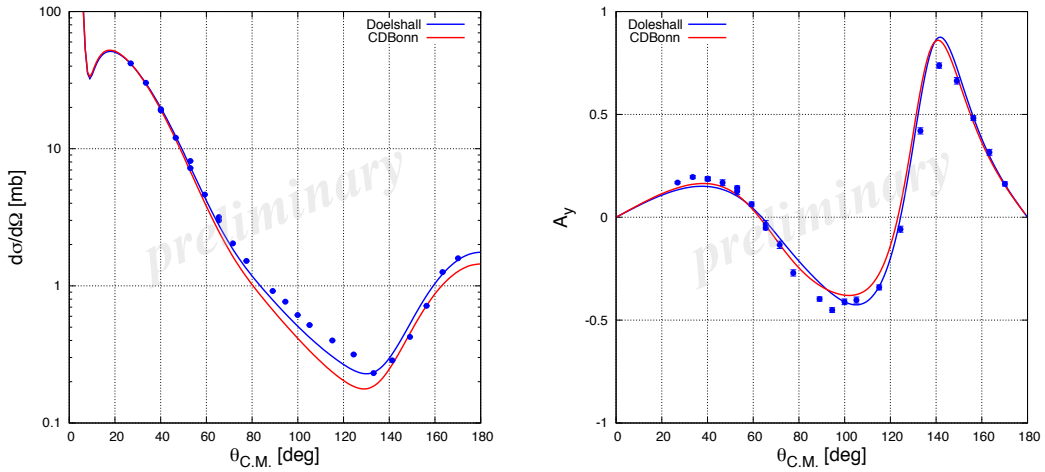

Figure 2: Cross sections and proton analyzing power A_y for the p–^{3}He elastic scattering at 65 MeV. The solid lines show the theoretical calculation based on the several realistic NN potentials.

References

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